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Granstrand, O. (2020). Towards a Theory of Innovation Governance and the Role of IPRs. GRUR International, 69(4): 341-354. http://dx.doi.org/10.1093/grurint/ikaa024

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GRUR International, 69(4), 2020, 341–354

doi: 10.1093/grurint/ikaa024
Article

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Towards a Theory of Innovation Governance and the Role of IPRs

This paper theorizes about innovation governance, especially about governance of open innovation and the nature and role of IPRs. A reinterpretation of open innovation is offered in terms of the emergence of various types of markets for inputs to and outputs from innovative activities. These *open innovation markets* are typically markets for ideas, technologies, knowledge and data such as licensing markets, equity markets, and matching markets for innovation collaborations and correspond to various types of open innovation strategies viewed from the inside out in a focal firm's perspective. Open innovation – seen as a set of quasi-integrated organizational forms for innovative activities in between market and hierarchical firm organizations – is then explainable in terms of determinants of supply and demand. Intellectual property rights (IPRs) then play a new role as tools for innovation governance, thereby economizing on governance costs in an extended transaction cost framework. Licensing of usage rights is key to using IPRs for innovation governance. The by now standard property rights approach to rights in intellectual resources has to be challenged, however, and referred to as 'intellectual rights' rather than IPRs. In addition, the governing role of IPRs can be improved by combining them with liabilities into a hybrid approach. Organizational responsibilities provide still another institutional arrangement for innovation governance, and integration of rights, liabilities and responsibilities provide a new theoretical perspective on innovation governance – a perspective that also can provide links between organization theory, transaction cost economics and property rights theory.

I. Background and purpose

As should be the case, much attention has been paid to the question of how to govern economic activities in general. Much less attention has been paid to the issue of how to govern R&D and innovative activities specifically, which should not be the case in light of the general consensus concerning the *sine qua non* role of new technologies and innovations for economic performance. The nature of new technologies and innovative activities has moreover changed drastically over the years, which further emphasizes the question whether the traditional economic and legal institutions – markets, firms, property rights, courts, etc. – are functioning satisfactorily for governing innovative activities in a capitalist market economy. At a higher level of inquiry the developments in China and the US in recent decades, and previously in the former Soviet, underline the question what forms of a market economy and a planned economy are superior for innovative performance, be it for military or civilian purposes.[1] At both levels the question of openness enters, that is, whether economies, markets and innovation processes should be open in some sense (to be specified below). As to market economies the traditional analysis of governance in the transaction cost economics (TCE) framework, originally developed in Coase (1937) and Williamson (1975), contrasts markets and firms as two main forms of organizing economic activities in general. In this framework firms will appear if governance costs, composed of market transaction costs and management costs, thereby can be lowered under certain assumptions. These two organizational forms could also be interpreted as polar types on a scale of organizational integration, ranging from fully decentralized and disintegrated market transactions to a fully integrated hierarchical organization with multi-level governance. Although Williamson and others have addressed the role of R&D, new technologies and innovation, over the years it is fair to say that innovative activities do not feature centrally in this framework even today.[2] The same comment holds for Coase's celebrated work on the key role of (physical) property rights for creating markets that can internalize externalities, later referred to as 'Coase theorem'.[3] Neither innovative activities with the purpose to reduce negative externalities, nor the role of intellectual property rights (IPRs), are addressed in the seminal work Coase (1960) and following works. Thus, innovative activities are to a considerable extent neglected in these prominent frameworks for economic analysis.[4]

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1 To address this question, one has to consider that the continuous emergence of technologies with dual civilian and military uses, often with civilian ones taking the lead, makes innovative activities and performance for civilian and military purposes intrinsically interdependent.

2 Oliver Williamson, personal communication.

3 The label 'Coase theorem' is attributed to G Stigler.

4 This holds for other prominent frameworks as well, eg general equilibrium theory originated by K Arrow and G Debreu. The neglect of innovative activities in mainstream economics has been heavily and even irreconcilably criticized by many economists over the years, especially since the seminal work by Richard R Nelson and Sidney G Winter, *An Evolutionary Theory of Economic Change* (Harvard University Press 1982). This work spurred the branching process of evolutionary economics, emphasizing in qualitative terms the key roles in the economy of

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At the same time as empirical studies have since long shown the key role of innovative activities carried out in firms and markets and in the economy as a whole, the nature of R&D, new technologies and innovative activities at large has changed dramatically. More recent empirical studies have e.g. shown the frequent appearance of quasi-integrated organizational forms for innovative activities, 'in between' the polar types of market and hierarchical organizations, today commonly referred to as 'open innovation'.[5] Many rationales for engaging in open innovation have been offered in the literature, but still this phenomenon needs to be better understood theoretically. A better theoretical understanding of the role of IPRs in open innovation is also needed, since some claim they help while others claim they hinder open innovation and empirical cases of both roles exist.

More generally, there is a need to theorize about how innovative activities are incentivized and coordinated, i.e. governed, in markets, in hierarchies and in mixes thereof, and the role of property rights in that context. As an economic and legal institution, property rights are pivotal in the sense that they can exist even in the absence of both markets and hierarchies, while neither of the latter can exist without property rights.[6] If this is so for physical property rights, what does that mean for IPRs? Moreover, at the same time as allocation of property rights is necessary for markets to function, allocation of organizational responsibilities is necessary for multi-level governance in hierarchical organizations to function. What is then the more fundamental relation between property rights and responsibilities from a governance perspective and from an innovation governance perspective more specifically? These are some of the issues that will be explored in this paper, questions which are large and demanding. Thus, only a few steps on a road less travelled can be taken here in the hope that further research will follow.

II. The changing nature of R&D and innovative activities

Innovations constitute a broad category, being by a usual definition new to all (i.e. new to the world) and useful to some (and thus possibly harmful to some). Characterizations must therefore be selective and interpreted as rough estimates of average tendencies. First, investments in R&D and innovation have on average grown and become more dispersed across countries, companies and other organizations around the world since WW2; similarly, total returns from investments have likely followed a similar pattern, although skewed and uncertain, while R&D productivity has fluctuated and possibly even declined.[7] More countries and companies also operate on the technological frontier in many areas, due to successful catch-up aided by industrial and business policies and R&D spill-overs. Second, innovations have moreover become composed of multiple complementary technologies and other bodies of knowledge, yielding economies of scope, however with multiple IPRs and IPR holders yielding transaction costs and infringement risks. Third, much R&D has at the same time become more fundamental and science based, resulting in new technologies being more generic or general purpose with multiple applications across products, processes and services, yielding economies of scale.[8] Thus, there are two general and interdependent tendencies in R&D and innovation: one towards increasing technological diversification with more multi-technology products, and one towards increasing technological 'genericness' with more multi-product technologies.[9] Fourth, innovative activities are also organized on increasingly larger scales, and since long based on intra-organizational teams rather than individual researchers and inventors, and more recently increasingly also based on inter-organizational teams. The latter teams are often quite heterogenous with firms, government agencies, universities and R&D institutes, possibly from several countries, covering many specialties and usually having different objectives. Innovations have also become more open in the sense that innovative activities are conducted across organizational boundaries in various ways, including but not limited to inter-organizational collaboration. This tendency appears both regarding the acquisition of resources for innovation and exploitation of results from innovative activities. In summary, resources for and results from innovative activities are increasingly traded on various types of markets, implying different degrees of organizational disintegration.[10] All these economic, technological and organizational tendencies as well as tendencies in the legal institutional framework, such as the expansion and strengthening of the IPR system worldwide, are interrelated in various ways, which will be dealt with in more detail below.

innovation and entrepreneurs in line with Schumpeter's century old message. At the same time R&D and innovation has been incorporated in several other areas of economics, eg in growth economics by Paul M Romer and others.

5 The term 'open innovation' was introduced by Henry Chesbrough, see Henry Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology* (Harvard Business School Press 2003) xxiv.

6 This proposition is further elaborated in Ove Granstrand, *Evolving Properties of Intellectual Capitalism: Patens and Innovations for Growth and Welfare* (Edward Elgar Publishing 2018).

7 See Granstrand (n 6) for some R&D statistics and a general literature review and in particular Bronwyn Hall, Jacques Mairesse and Pierre Mohnen, 'Measuring the Returns to R&D' in Bronwyn Hall and Nathan Rosenberg (eds), *Handbook of the Economics of Innovation* (Elsevier 2010) 1033-82 for a review of statistical studies of returns to R&D, and Nicholas Bloom and others, 'Are Ideas Getting Harder to Find?' (NBER Working Paper No 23782, Cambridge, MA: National Bureau of Economic Research 2017) for statistics on R&D productivity.

8 See Ove Granstrand, Pari Patel and Keith Pavitt, 'Multi-Technology Corporations: Why They Have "Distributed" Rather than "Distinctive" Core Competencies' 39 (4) California Management Review 8-25 (1997) and John Cantwell, Alfonso Gambardella and Ove Granstrand, *The Economics and Management of Technological Diversification* (Routledge 2004) on technological diversity, and Timothy F Bresnahan and Manuel Trajtenberg, 'General Purpose Technology "Engines of Growth"?' 65 (1) Journal of Econometrics 83-108 (1995) on technological genericness.

9 How these tendencies interact is described in Ove Granstrand, 'Towards a Theory of the Technology-Based Firm' 27 (5) Research Policy 465-89 (1998). Generic or general-purpose digital information and communication technologies in particular pervade many products and processes and thereby contribute to their technological diversity, as do new material technologies.

10 In fact, international technology trade through licensing is growing fast, even in many cases faster than international product trade although estimates are uncertain.

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III. Open innovation management and open innovation markets

Open innovation is a fairly new term for an old phenomenon.[11] From a focal firm's point of view open innovation refers to the various ways or strategies the firm can employ to acquire inputs from outside sources (e.g. users, suppliers, competitors, complementors, universities) to its innovative activities as well as the various strategies to exploit the results from its innovative activities, referred to as 'inbound' and 'outbound' open innovation respectively. These strategies include acquisitions and spin-offs of innovative firms and projects, inter-organizational collaborations, and in- and out-licensing of technologies. Thus the various forms of open innovation differ from the more traditional vertically integrated form of innovation with in-house R&D and in-house production and marketing.[12] The difference is essentially that open innovation relies on some type of technology or knowledge market while a vertically integrated firm relies on labor and product markets for R&D inputs and product markets for innovative outputs. At the other end of the spectrum of organizational integration is the market for fully disintegrated ownership rights in technology and knowledge, i.e. the market for 'naked IP' without being bundled (integrated) with other intellectual resources, e.g. the market for patents.[13]

Hence open innovation could be seen as corresponding to a set of quasi-integrated organizational forms. The degree of organizational integration of innovative activities could in principle be operationalized, at least partially, based on the nature of the contracts used for transacting on the different markets, ranging from the employment contract in a fully integrated organization to a simple licensing contract, with collaboration contracts somewhere in between as illustrated in Figure 1.[14]

The operationalization in the figure is approximate in light of the numerous contractual variations and could be refined. Nevertheless, the typology specifies the various quasi-integrated forms of inbound and outbound open innovation and their associated types of contracts.

However, the main point here is not to operationalize but to reinterpret the phenomenon of open innovation in terms of (technology) markets rather than (technology) strategies. This means using an outside-in perspective on open innovation rather than an inside-out perspective from a focal firm's point of view. Each type of open innovation strategy employed then corresponds to a management decision to use a specific type of market as illustrated in Figure 2.

These markets involving open innovation can be referred to as *open innovation markets*, of which there are several types as shown in the figure. Each type of open innovation market then has characteristics as to its buyers and sellers, demand and supply conditions, intermediaries, information sets, nature of technology transacted, pricing process, typical contracts, etc. Some of these characteristics are common to most or all of these markets. All of them are to some extent markets for intangibles or intellectual capital in the form of information and ideas, although often bundled with tangible resources as well. They are also often forward looking in the sense that they involve future deliveries of information, e.g. in the form of targeted R&D results or software upgrades. In many cases the contractual relations are long range, e.g. in know-how or patent licensing. Moreover, these markets are typically two-sided in the sense that both buyers and sellers hold preferences about each other. This is especially so for matching markets for R&D joint ventures and innovation collaborations, but also licensing markets and the equity markets for acquisitions and spin-offs are usually two-sided. Technology markets are also typically thin, with small numbers of buyers and sellers, and opaque and information asymmetries and intermediaries (consultants, brokers, dealers, etc.) are common.

All in all, these open innovation markets for ideas, information, data, and knowledge in general are complex with all the traditional drivers of transaction costs being present to a considerable degree, i.e. small numbers, opportunism, uncertainty and bounded rationality. Now if transaction costs are high on these markets, would there not be a tendency over time for firms to form in order to internalize transactions and thereby economize on transaction costs as predicted in the transaction cost framework? The open innovation phenomenon then seemingly runs counter to this prediction. To deal with this question a number of considerations are called for. First, the transaction cost concept has to be scrutinized. In case only the two organizational forms – markets and firms (representing hierarchies) – are compared, management costs for hierarchical governance could in principle be subsumed into transaction costs by considering the transaction costs on markets net of management costs in firms (similar to the use of opportunity costs when comparing two alternatives). In the case of traditional markets vs. hierarchies analysis, transaction costs on markets are compared to the costs of hierarchical governance and if the latter costs are persistently lower, hierarchical governance (e.g. through firms) will appear. In the case of quasi-integrated organizational forms of governance 'in between' traditional markets and hierarchies, i.e. the type of technology and innovation markets described above, a concept of total governance cost has to be explicitly considered. Governance cost is then composed of market transaction costs, including the transaction costs on technology markets, and management costs, the latter including costs of hierarchical governance as well as costs for managing open innovation (e.g. managing an R&D joint venture). The traditional transaction cost analysis of two polar types of organization, i.e. markets and firms, in terms of

11 An early large-scale empirical study of European multinational corporations (MNCs) identified various inbound and outbound company strategies and organizational structures corresponding to various forms of open innovation, reported by Ove Granstrand, *Technology, Management and Markets: An Investigation of R & D and Innovation in Industrial Organizations* (Pinter 1982) 66, 197, 202-3. These forms included vertical and horizontal innovation collaborations (joint ventures), in- and outlicensing and acquisitions and spin-offs of small innovative firms or projects, and were referred to as quasi-integrated organizational forms in a transaction cost framework, based on Oliver E Williamson, *Markets and Hierarchies: Analysis and Antitrust Implications – A Study in the Economics of Internal Organization* (New York Public Library 1975).

12 The vertically integrated form of innovation is referred to as closed innovation in Chesbrough (n 5) xx.

13 This type of market is sometimes referred to as the secondary technology market, with patent auctions and sales of patent portfolios as examples. The patent license market could then be seen as a derivative market with patent rights as the primary security, see Granstrand (n 6) 333.

14 An empirical study using this operationalization is reported in Ove Granstrand and others, 'External technology acquisition in large multi-technology corporations' 22 (2) R&D Management 111-134 (1992).

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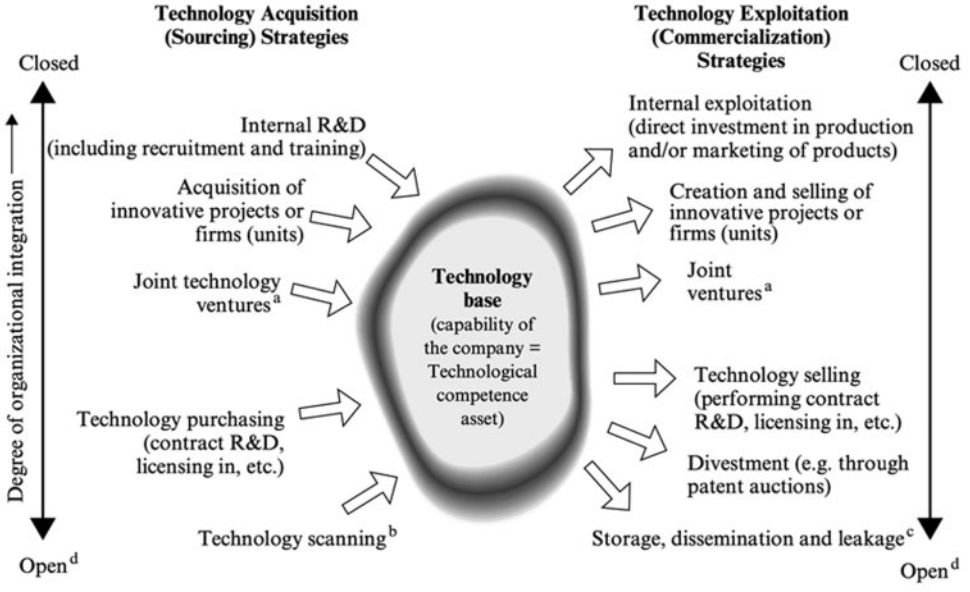

Figure 1: Open and closed strategies for acquisition and exploitation of technology

Notes: [a] Joint ventures (partnering, collaborations) refers to inter-organizational cooperation in general – not necessarily formalized.

[b] Scanning includes legal and illegal forms of acquiring technological know-how from the outside without any direct purchasing from its original source. Receiving technology (e.g. patents) for free, i.e. receiving patent donations, falls into this category.

[c] This is not a strategy for exploitation but a kind of residue of 'unappropriated' technology, possibly leaking to competitors through their technology scanning efforts. Outward patent donations also fall into this category.

[d] The degrees of openness or organizational integration for the various strategies are based on the length and strength of the underlying contractual relations implied by the strategies. As the contracts used might differ in different cases, the ordering might differ, e.g. regarding acquisition and sales of various amounts of stock in firms.

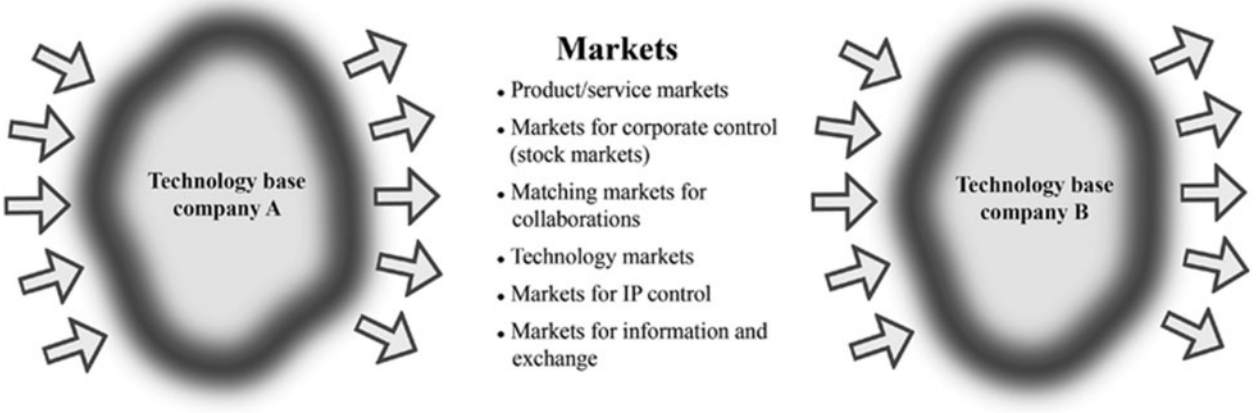

Figure 2: Markets for open and closed innovation connecting various technology-based entities

relative transaction costs becomes inadequate when more than two organizational types are analyzed – three in our case here if open innovation is considered a third type. The transaction cost concept has then to be extended and complemented with management costs. The analysis of more than two organizational types then becomes much more complicated and predictions on primarily analytical grounds with little empirical founding become very uncertain (cf. the 'three-body problem' in physics). In general, the determinants of transaction costs mentioned above are also increasing management costs, and it is difficult to assess the difference, a difficulty that is aggravated in case the determinants of transaction costs and management costs differ in kind rather than in degree. These difficulties could be expected to be even more pronounced in case of innovative activities compared to regular production activities, e.g. regarding uncertainty resolution, monitoring, incomplete contingency contracting, and trust building. Second, not only transaction costs and management costs have to be considered but also the time aspects and the total innovation production cost aspects of the kind of make/buy decision involved in open innovation. Empirical studies of the motives to engage in inbound open innovation also point at the attainable time and total cost savings together with risk sharing.[15] Third, transaction costs as well as management costs are dynamic, and may change as a result of many factors, including learning by transacting and technological changes (e.g. in information and communication technologies).

15 See eg Granstrand and others (n 14).

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Reorganization also incurs fixed costs and thus inertia in adapting organizational modes to fluctuating governance costs. Fourth, one has to consider how markets are formed, not only how firms are formed. The view in TCE, crudely expressed that in the beginning there were markets and then firms were formed, bypasses the fact that markets are created, sometimes spontaneously, sometimes by market design, and markets disappear.[16] This fourth point will be elaborated next, albeit briefly.

Technology markets, and open innovation markets more broadly, are not created simply by some firms deciding to engage in open innovation. On the other hand, functioning technology and innovation markets involve open innovation, so in that sense the creation of such markets is decisive for open innovation. Generally speaking a new market is created when a new type of transaction of an object starts to occur in encounters between buyers and sellers as contractual subjects.[17] A necessary condition then is that there exist some buyers with a willingness to pay (i.e. buy) exceeding the willingness to sell of some sellers, in which case the difference enables the creation of value through a transaction.[18] Theoretically the willingness to buy and sell could be expressed quantitively in monetary terms or more generally in utility terms. Empirically that is difficult in a new and uncertain market situation, and then various types of qualitative motives to buy and sell enter into the decision process. For open innovation markets such as technology licensing markets, innovation equity markets and innovation collaboration markets, there are several motives to engage in inbound and outbound open innovation, i.e. motives to buy rather than make, to sell rather than keep or to collaborate. Generally speaking, empirical studies of the motives to engage in inbound open innovation point at the attainable time and (total) cost savings together with risk sharing as mentioned. Motives to engage in outbound open innovation point at attainable revenues as well as speed to market and risk sharing.[19]

More specific motives are associated with the different types of open innovation markets. To exemplify, motives to license out a new technology may involve a preference for returns on investments in R&D rather than sales growth through in-house production and marketing, while in-licensing may in some cases be motivated by a perceived need to challenge in-house R&D with a substitute technology and thereby intentionally create internal competition. Motives to acquire small innovative firms rather than performing early stage R&D in-house may involve a view that the in-house organization is not adapted to those kinds of innovative activities. Reversely, spinning off innovative activities in the form of an R&D project or small innovation company may be motivated on the grounds that it does not fit in with the company strategy. Innovation collaborations, be they inbound, outbound or both, with users, suppliers, competitors, complementors, independent inventors, universities, governments etc. may be motivated in various ways at various stages (e.g. competitive or pre-competitive) of the innovation process by economies of scale (e.g. in the case of large scale experimental equipment), economies of scope (e.g. in the case of complementary competences across collaborators), economies of speed (e.g. in the case of in-house resource constraints and coordination problems in concurrent engineering) and location (e.g. in the case of geographical and cultural proximity to universities).

Thus, there is a plethora of various types of motives for entering open innovation markets. However, the main question here is not primarily how to motivate open innovation and entry into various innovation markets but how to explain the emergence of the latter as a way to explain the open innovation phenomenon and the proliferation of markets for open innovation. That means a joint analysis of both the supply and demand side of innovation markets, i.e. an analysis that goes beyond the specific motives to engage in inbound and/or outbound open innovation. The changing nature of transaction objects and the way they are produced, i.e. the changing nature of new technologies and R&D, together with changes in the surrounding economic and legal institutional framework should then be considered in addition to managerial motives. An important change in the legal institutional framework is the emergence of the pro-IP era since the 1980s, which has considerably strengthened IPRs and their role for open innovation markets.[20]

IV. Supply and demand drivers on open innovation markets

Several determinants of the supply of and demand for new technologies on technology markets could be identified related to the changes in the nature of new technologies and R&D described earlier. First, there is an increased technological levelling around the world with reduced (but far from removed) technological gaps across many countries and companies. Thus, more actors arrive at the technological frontiers and participate in frontier R&D in various areas. This is due to technological catch-up (typically based on inbound open innovation in fact, thereby driving demand on technology markets) and creates competitive pressures to supply new technologies on the market even if many sub-markets are thin and

16 See especially Alvin E Roth, *Who Gets What – and Why: The New Economics of Matchmaking and Market Design* (Houghton Mifflin Harcourt 2015) on market design.

17 To become operational this definition needs a specification of newness or novelty, which is not a trivial matter, eg in anti-trust cases. Even in case novelty is taken as newness to the world, as in patent granting, deciding what is new in practice is not trivial. This issue is left aside here, except for noting that the concept of newness here is linked to the type of transaction relation, which may be considered new to the extent that the type of transaction objects or subjects or the type of contract or the mode of transaction is new.

18 Roughly speaking a pricing decision then distributes the value created between buyer and seller. Fair pricing in some sense, eg as used in fair, reasonable and non-discriminatory (FRAND) based licensing, then differs from competitive pricing and can be used for more equitable than solely efficient value distribution.

19 See eg Granstrand and others (n 14), Ashish Arora, Andrea Fosfuri and Alfonso Gambardella, *Markets for Technology: The Economics of Innovation and Corporate Strategy* (The MIT Press 2001) and Ove Granstrand, 'The Economics and Management of Technology Trade: Towards a Pro-Licensing Era?' 27 (2/3) International Journal of Technology Management 209-40 (2004).

20 Much has been written on this change, see eg Ove Granstrand, *The Economics and Management of Intellectual Property: Towards Intellectual Capitalism* (Edward Elgar Publishing 1999), Granstrand (n 6), Adam B Jaffe, 'The U.S. Patent System in Transition: Policy Innovation and the Innovation Process' 29 Research Policy 531-57 (2000), Bronwyn Hall, 'Exploring the Patent Explosion' 30 (1-2) The Journal of Technology Transfer 35-48 (2004), Benjamin Coriat and Fabienne Orsi, 'Establishing a New Intellectual Property Rights Regime in the United States: Origins, Content and Problems' 31 (8-9) Research Policy 1491-507 (2002).

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two-sided. Second, the appearance of generic technologies or general purpose technologies (GPTs) induce firms and other technology and innovation producers to out-license such technologies for applications outside their immediate business areas. However, generic technologies do not arrive recognizable as such and ready-made for multiple applications, but their generic nature has to be identified and developed over time, typically by multiple parties interacting and transacting in dual roles as users and producers, thereby intertwining the demand and supply side of the corresponding technology markets.

Third, technological diversification, i.e. increasing diversity of technologies of products as well as firms, thereby becoming increasingly multi-technological, increases costs and times for in-house R&D to the point that not even the largest firms can afford to be technologically self-sufficient in all complementary technologies. Firms then have to resort to open innovation markets to lower or share costs and risks and lower times to final product markets. Production learning curves and other common sources of increasing returns reinforce early mover advantages and economies of speed to market. In the face of technological diversification, open innovation markets thus offer economies of scale, scope and speed.

Fourth, specialization and division of labor in R&D and innovative activities in order to reap economies of scale spurs both supply and demand for new technologies when different specialties are difficult to organize and coordinate in-house. This might be the case for radically new substitute and possibly disruptive technologies or small scale R&D work running the risk to be marginalized in a large organization or some organizational limits in general.[21] Small firms could for instance specialize in early R&D stages and aim for being acquired by large firms specializing in later innovation stages with more costly R&D, production and marketing.[22] The pharmaceutical industry provides a good example of this type of industrial organization of innovative activities.[23] Some R&D and technology providers such as universities or government institutes simply cannot economically or legally build up all the necessary complementary assets for integrated innovation and hence are referred to supply technology markets. As to universities, this type of actor has transformed into an important economic institution in the post-WW2 era and has become an important supplier of new technologies and start-up companies, enabled by new legislation in various countries.[24]

Fifth, the increasing economic scale of R&D with increasing costs and times has called for more means for innovation financing such as outlicensing, offerings on equity markets and joint ventures. The role of IPRs for financing of large innovation projects in various stages has then increased, spurred by the emergence of venture capital markets. Thus, open innovation markets also function as markets for financing innovative activities at various stages of the innovation process.

Sixth and finally, there are other miscellaneous technology-related circumstances that increase supply and demand on open innovation markets, such as provisions for open compatibility standards or tax planning based on intra-firm licensing of in-house R&D results.

In summary, a number of drivers of demand and supply on open innovation markets can be identified. Many of these drivers increase both demand and supply but not necessarily simultaneously but rather over time. The drivers are moreover interacting as described above, which typically makes technology markets interrelated both as to their transacting subjects and their transaction objects.

V. The theoretical rationales behind IPRs

Ideas and information have as intangible objects some intrinsic characteristics fundamentally different from tangible (physical) objects. The differences are obvious, while the consequences are profound and might be less obvious. First, ideas and information embedded in humans cannot be directly observed, nor can they be dispossessed in the same way as physical objects might be, with the consequence that property rights based on first and sole possession cannot be assigned or enforced in the same way as with physical objects. Moreover, individuals can keep ideas and information secret, but once disclosed this type of control is lost. Thus, possession of an idea is initially controllable but sole possession is not guaranteed.[25]

These three characteristics – unobservability, dispossession impossibility and limited controllability – of human information processing are basically due to the physiology of humans and thus can be viewed as biologically founded.[26] These characteristics limit the possibilities for humans to trade ideas and information as cogently described in Arrow (1962), since a seller has to disclose some information about what is being offered to a buyer, who then permanently possesses that information without a transaction.[27] Transacting parties then simply cannot resolve a dispute bilaterally. To facilitate trade in ideas and information some kind of institutional approach with a third party is essential, albeit not necessary as witnessed by the volume of know-how trade and transfer taking place without the use of a third party. Such an institution has to create some property-like rights in order for efficient market exchange to take place.[28] Such property rights in ideas and information require a priority basis for granting new rights to some individual or entity, which in turn requires some kind of registrar. There are reasons, not only historic but economic, to let the priority basis for rights in ideas and information induce a race among contestants by using some kind of a first-to-act rule for deciding priority. Because of limited observability, a rule like first-to-create is

21 See eg Edith Penrose, *The Theory of the Growth of the Firm* (Blackwell 1959) and Kenneth J Arrow, *The Limits of Organization* (WW Norton & Company 1974).
22 This type of 'innovation system' was early on described by Williamson (n 11) 196-199 but was practiced even earlier.
23 See eg Arora, Fosfuri and Gambardella (n 19).
24 Eg the Bayh-Dole act in the US.
25 In particular a new business or technological idea is controllable as long as it is held in some secrecy. One can moreover argue that the embryo of a new firm is this form of IP.
26 Limited controllability is in fact implied by the other two characteristics but put on a par with them here for clarity.
27 This circumstance is often referred to as 'the information paradox', a term not coined by K Arrow, however (personal communication).
28 If transacting parties benefit from recurrent contracting and reputation, then trust building and concomitant information exchange may take place without explicit property rights. A case in point is pure know-how licensing. However, markets do not function in general without some kind of property-like rights or means of control involving rights or means of some enforceable strength to exclude, dispose, transfer and exploit.

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less operational than a first-to-register type of rule, such as first-to-file rather than first-to-invent.[29]

Thus, the institutions created for granting rights in new technological ideas and information (inventions), i.e. the patent system, could in principle (apart from parametric features like inventive step, duration of rights, etc.) be derived from the physiological characteristics of human information processing and the need for facilitating market exchange of information across humans in more developed societies. This view reinforces the traditional utilitarian rationale behind instituting some form of patent system, i.e. that it meets the need to correct for underinvestment in R&D due to appropriability problems for innovators, due in turn to R&D externalities (spill-overs), favoring imitations rather than innovations, and at the same time creating value for society through increased provision of innovations. This rationale can in turn be challenged on several grounds even if it is valid. First, underinvestment might not occur, e.g. due to racing tendencies in R&D and innovation, races that might be reinforced by patent races, leading to overinvestment. Second, sufficient appropriability may be secured by firms and other R&D investors through other means, such as through control of complementary assets or speed to market without the help of patents. Third, there might be better institutions or policies to correct for any underinvestment, such as R&D buyouts or innovation procurement. Fourth, the patent system might correct for an underinvestment but lead to unwanted and costly side effects, like monopolistic overpricing and distorted innovative activities.[30] There are also rationales for keeping a patent system once it is in place. A conservative view is that it would be costly and risky to abolish an existing patent system, given the uncertainty about its effects. A more defeatist view is that some kind of patent system would reappear anyway if abolished, due to the strength of factors that once put it in place. A reformist view is that it is better to fix the system than to abolish it.[31] Table 1 summarizes the traditional utilitarian rationales or economic motives or theories behind a patent system, together with new ones, of which the governance perspective is of particular interest here.

VI. IPRs as tools for innovation governance[32]

A fairly recently developing view and justification of IPRs is their functionality for governance in and of innovation systems as described in the literature and evidenced in various new IP phenomena.[33] The governing functions of IPRs could be performed at three main levels: the level of society and their representative governments, the level of markets, and the level of organizations of various kinds (companies, universities, etc.) in the profit as well as in the non-profit sector of society. At these levels the IPR system provides a contractual infrastructure which provides a pre-contract market signaling function, a set of pre-defined and standardized contractual arrangements and rules for reaching as well as transferring or trading contractual agreements and mechanisms for their enforcement, even post-contractually. Physical property rights (PPRs), i.e. property rights in tangibles, provide similar important functionalities. However, it may be argued that the intrinsically more complex nature of intellectual resources and IPRs compared to physical resources and their PPRs makes the availability and functioning of such a contractual infrastructure even more important for well-functioning trade and transfer of IP. Signaling of the possession or non-possession is easier for tangibles than for intangibles, for example. Also, dispossession is easier for tangibles than for intangibles (for which it is impossible when embedded in humans) which makes enforcement, including self-enforcement, easier for tangibles than for intangibles. Circumstances like these speak in favor of having some type of 'paper titles' or tangible registration together with criteria of possession as grounds for ownership of intangibles, i.e. as grounds for intellectual property.[34] At the same time the complexity of intellectual resources could be used as an argument for abandoning the property approach altogether.[35] The reference point is then the functioning of PPRs and their important role historically in economic development.[36] This has prompted calls for patent reforms to make patent rights work more efficiently as property rights.[37] Even if the prospects for this approach are limited by the complexity of intellectual (intangible) resources compared to physical (tangible) resources, it may still be a feasible approach, let alone an optimal approach relative to its alternatives.

However, property rights, be they PPRs or IPRs, are neither monolithic nor static, but consist of bundles of rights, which may be changed over time regarding both the individual rights in the bundle and the composition of the bundle.[38] A property rights bundle entitles its holder

29 In other areas of creation, rules like first-to-publish rather than first-to-write, and first-to-exhibit rather than first-to-paint are conceivable for making attributions.

30 There is a rich literature on the rationales or motives behind a patent system, see eg Suzanne Scotchmer, *Innovation and Incentives* (The MIT Press 2004) and Katharine Rockett, 'Property Rights and Invention' in Bronwyn Hall and Nathan Rosenberg (eds), *Handbook of the Economics of Innovation* (Elsevier 2010) 315-80 for formal economic theorizing and Matthias Lamping and Reto M Hilty, 'Patent Declaration: Reasons and Purposes' 6(3) UC Irvine Law Review 469-82 (2016), Granstrand (n 6) and Toshiko Takenaka, *Research Handbook on Patent Law and Theory* (Edward Elgar Publ 2019) for recent qualitative surveys.

31 Fritz Machlup, *An Economic Review of the Patent System: Study No 15 of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary* (US Government Printing Office 1958) 80 expresses the conservative view in an often-cited passage.

32 This section draws on Granstrand (n 6) ch 10).

33 See Ove Granstrand, 'Intellectual Property Rights for Governance in and of Innovation Systems' in Birgitte Andersen (ed), *Intellectual Property Rights: Innovation, Governance and the Institutional Environment* (Edward Elgar Publishing 2006) 311-44 and Granstrand (n 6).

34 Such a mixed system could be motivated for property rights in tangibles as well, see William M Landes and Richard A Posner, *The Economic Structure of Intellectual Property Law* (Harvard University Press 2003).

35 See eg Paul A David, 'Intellectual Property Institutions and the Panda's Thumb: Patents, Copyrights, and Trade Secrets in Economic Theory and History' in Mitchel B Wallerstein, Mary E Mogee and Robin A Schoen (eds), *Global Dimensions of Intellectual Property Rights in Science and Technology* (The National Academies Press 1993) 19-61, Landes and Posner (n 34) and Robert P Merges, *Justifying Intellectual Property* (Harvard University Press 2011) among many others for discussions of this argument.

36 Many scholars have emphasized this role, see Douglass C North, *Structure and Change in Economic History* (Norton & Company 1981) in particular.

37 See James E Bessen and Michael J Meurer, *Patent Failure: How Judges, Bureaucrats, and Lawyers Put Innovators at Risk* (Princeton University Press 2008) for a good example.

38 A bundle of rights may also be associated with a bundle of obligations. In case of patents, the design of an obligation bundle is not so much discussed. Enabling disclosure could be seen as an obligation, but others are conceivable and may even be recommendable, like a patent notice as advocated in Bessen and Meurer (n 37) and disclosure of patent assignments and license terms as advocated in Mark A Lemley and Nathan Myhrvold, 'How to Make a Patent Market' 36 (2) Hofstra Law

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Table 1 Economic motives for the patent system

Received economic theories	Newer economic perspectives on patents
Incentive-to-invent theory Focus: Impact on invention and R&D. Concerns: • Distortion of R&D (e.g. too many substitutes/too few complements, too little basic/too much applied, too many patentable/too few unpatentable) • Barriers to competition • Heterogeneity of industries/firms/inventors	*Patents as a joint incentive to innovate, diffuse and trade* Focus: Impact on dynamic competition through 'continuous' and entangled (interdependent) innovation and diffusion processes. Concerns: • As for incentive-to-innovate • Efficiency/distortion of diffusion • Interdependence of inventions and innovations over time (e.g. in sequential innovation) • Dynamic interaction between innovation and diffusion processes • Technology market efficiency • Role of patents in financing and cash management
Incentive-to-disclose theory Focus: Impact on secrecy. Concerns: • Quality/quantity of disclosure • Impact on R&D (e.g. stimulation, coordination) • Impact on diffusion (e.g. on technology markets)	*Patent rights and patent information as a governance mechanism* Focus: Property rights allocation and disclosure as a mode of incentivizing and organizing for decentralized governance through management hierarchies and markets and hybrids of these two governance modes. Concerns: • Allocation and transfer of rights • Cumulation and dispersion of rights • Interdependence of rights • Scope and duration of rights • Enforcement of rights • Governance efficiencies, e.g. in terms of coordination and communication costs, e.g. market efficiencies, e.g. in terms of transaction costs • Optimal decentralized 'tariffs' or 'taxation' (through prices or damages) • Role and efficiency of governance bodies and institutions (legislators, courts, patent offices, patent management, patent pools, clearing houses, anti-trust authorities, etc.) and risks of regulatory capture • Alternative governance mechanisms
Incentive-to-innovate theory Focus: Impact on innovation and competition Concerns: • Incentives *ex ante* and *ex post* invention • Impact on complementary investments • Transaction costs • Invention/innovation distinction • Patent scope and duration	
Prospect theory Focus: Resource exploitation efficiency. Concerns: • Coordination and duplication of R&D • Exploration • Improvement • Firm strategies	

Source: Ove Granstrand, *Evolving Properties of Intellectual Capitalism: Patens and Innovations for Growth and Welfare* (Edward Elgar Publishing 2018)

to a degree of control over a resource, which in strong form amounts to ownership of the resource. Typically, a property rights bundle consists of a right to use the resource, a right to exclude others from using it, a right to transfer the bundle to another holder, and a right to claim some or all of the value the resource might generate. As there are intrinsic differences between physical and intellectual resources, as shown in Table 2, it is natural that these differences are reflected in differences in the bundle of rights, as shown in Table 3 for the current IPR system. Any attempts or circumstances that amount to reducing these differences in the corresponding rights bundles thus ought to be scrutinized, e.g. attempts to extend the PPR system to the IPR system or circumstances like bundling of physical and intellectual resources. Thus, it is not clear that, for instance excludability ought to be as strong and/or wide-reaching for intellectual resources as for physical ones, at least not from a consequential utilitarian point of view, which is the by far dominating justification of the patent system. If strict excludability is abandoned from the patent rights bundle, one may claim that the remaining patent rights bundle no longer constitutes a property right on the grounds that strict excludability is a defining characteristic of a property right.[39] One might then argue that patent rights without strong excludability

Review 257-9 (2007). An obligation to 'work the patent', ie to use it in physical products or processes, within a certain time limit, as is the case for trademarks in some countries, is also conceivable but perhaps not recommendable.

39 As argued in Richard A Epstein 'The Property Rights Movement and Intellectual Property' 30 (58) Regulation 58-63 (2008).

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Table 2 Comparison of physical and intellectual property/resources[1)]

Variable	Physical property/ resource	Intellectual property/resource
Physical transferability among humans (in a strict sense)[2)]	Possible	Impossible (only sharable)
Dispossession	Possible	Impossible
Physical observability/signaling[3)]	Possible	Impossible (unless physically embodied or disclosed)
Rivalries in use	Yes	No
Excludability/controllability	Possible	Limited but possible with technical means. On/off control of secrets[5)]
Marginal cost of reproduction	Non-zero	Zero (by and large)
Definability/verifiability	Possible (mostly)	Limited
Fragmentation[4)]	Possible	Possible
Concentration/aggregation[4)]	Possible	Possible
Multi-agent pooling of resources	Possible	Possible
Appropriability	High	Low
Self-enforcement	High	Low

Notes:
[1)] 'Property' here simply stands for a resource that is in the possessive, but not necessarily exclusive, control of some individual or group. Control is a matter of degree in turn, which in strong form enables excludability.
[2)] Transfer meaning an addition on the receiving end and a subtraction on the sending end, obeying nominal arithmetic (algebraic) rules. Subtraction then corresponds to dispossession. Thus, the algebraic rules for trade and transfer fundamentally differ between physical and intellectual resources.
[3)] Observability of a resource is different from observability of the possessor or owner of a resource. The latter is difficult for physical resources as well in the absence of some kind of registration system.
[4)] Many complementary resources under possessive control by many and few agents respectively.
[5)] That is, an individual's secret is highly controllable but highly and irreversibly uncontrollable once it is disclosed.

could rather be more properly referred to as a type of intellectual rights, which in fact was a term used in Europe in the nineteenth century before the property rights approach to intellectual resources became dominant and before it became customary to use the term IPRs. More importantly, one may argue that the design and redesign of an IPR property-like rights bundle should, at least when it comes to patents, be governed by utilitarian and economic considerations rather than by an absolute property rights approach rooted in moral rights and deontological justifications, regardless of definitional issues. In other words a weakening of excludability, for example, could be justified on the grounds that it results in an overall welfare gain.[40] This is in accordance with a liability approach to patents, an approach that will be returned to below.

When IPRs, as we know them, are viewed as property rights their functionalities and dysfunctionalities or problems derive partly from the properties of PPRs, although only partly since physical and intellectual resources have intrinsic differences as displayed in Table 2, differences which limit the concordance of PPRs and IPRs as legal constructs as displayed in Table 3. Legal uncertainty, disputes, transaction costs, enforcement costs, problems with fragmentation and dispersion of rights and so on adhere to IPRs as well as to PPRs, and it is an open question whether the problems in these respects are larger for IPRs than for PPRs in total.[41]

Property rights in general, be they PPRs or IPRs, have a number of well-recognized functionalities in common, such as enabling trade, decentralized decision-making, and contracting and incentivizing efficient resource utilization. A particular feature distinguishing IPRs from PPRs is that they cannot rely on first and sole possession as a defining characteristic since human possession of intellectual resources (knowledge) cannot be inspected, dispossessed or literally transferred, as described above. Thus, IPRs need to be transacted with provisions enabling some kind of post-transactional mutual control of the underlying intellectual resource (or asset or capital). This feature has important implications, e.g. for the notion of organizational boundaries and the degree of integration. Needless to say, there are many other differences between IPRs and PPRs.[42]

The view (or emerging paradigm) of IPRs as governance tools at various levels leads to several issues to probe. First, IPRs, and patents in particular, are granted in return for disclosure of proprietary or privately held and guarded knowledge. Dissemination of patent information then helps inter-organizational coordination of R&D across firms, industries and nations, as does in fact patent litigation and its associated information to some

40 See eg Paul M Romer, 'When Should We Use Intellectual Property Rights?' 92 (2) The American Economic Review 213-16 (2002) for analysis along these lines in the case of unauthorized file sharing of music.

41 Probably they are not at present (as of 2019). The number of disputes that go to trial is larger for PPRs and disproportionately so if the value of IPRs and intellectual capital relative to PPRs and physical capital is considered. Territorial conflicts provide an example on a grand scale of the dominance of conflicts over physical resources.

42 One more vague type of difference pointed out in discussions with (Western) legal scholars is that limitations to entitlements associated with PRs have emerged more for PPRs (such as real estate) than for IPRs over the years. Allegedly this is also reflected in the attitudes and presumptions by eg patent lawyers.

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Table 3 Comparison of physical and intellectual property rights

Variable	Physical property rights	Intellectual property rights
Propertization and allocation	Most physical resources are already propertized and most rights are reallocated transactionally (through purchase, gifts, heritage, etc.)	Rights possibly granted upon application, examination and acceptance with direct government agency involvement, and reallocated transactionally in an evolving process of creation of rights
Duration	Permanent (linked to resource existence)	Temporary by statutes (except for trade secrets) and non-extendable (except for trademarks and certain data bases)
Registration	Partially registered. Flow of rights linked to resource flow	Granted and registered (mostly) upon application and examination, providing a flow of often interdependent rights
Exhaustibility	Exhaustive	Non-exhaustive
Transferability	Transferable	Transferable
Exclusivity	Provide (limited but not time limited) exclusivity	Provide (limited, also time limited) exclusivity
Function	Provide investment and efficient exploitation incentives (provided that validity, boundaries, and ownership is clear and transparent and transaction/assembly costs are low)	Provide investment and efficient exploitation incentives
Problems	Commons problem: Too many rights holders with rights to the same resource Anti-commons problem: Too many rights holders with rights to different complementary resources	

extent as well, although being a costly and time-consuming form of coordination.[43] The efficiency of this coordination, taking governance costs into account, is largely an open question and must be left to further research. Nevertheless, the effectiveness of this coordination is indicated by the long-lasting existence and use of the disclosure function of IPRs, as well as by some empirical studies, albeit so far sparse. [44]

Second, the IPR system facilitates trade and transfer of IP through licensing. As is well known among licensing professionals, there are numerous ways to tailor a licensing agreement in complex deals, using a variety of license types and payment schemes that altogether govern flows of new technologies and knowledge resources, rights allocations to them, knowledge sharing and sharing of revenue and risk. In fact, one could boldly assert that almost any actual or desirable communication structure among actors involved in innovation collaborations could be replicated by a formal licensing arrangement. Such an arrangement is not without cost, however. Implicit, informal contracting based on (business) cultural norms, which are enforceable through recurrent contracting, might be cheaper, as its prevalence among actors shows, especially when their stakes are not high. However, at the same time it is important to keep in mind the flexibility and adaptability of licensing agreements made formal. The formalism with all its pros and cons may then pay off when stakes (costs, revenues, risks) are high and prospects of recurrent contracting are low, and disputes are likely. Needless to say, formalism also carries other types of costs, e.g. in the form of losses of economies of hope and optimism in the presence of uncertainty, enthusiasm, flexibility, creativity, spontaneous encounters and cross-fertilization – costs which have to be factored in.

Third, licensing could also be used internally by firms not only to govern intra-firm technology transfer but also for financing in-house R&D as well as for corporate venturing. A case in point is the use of intra-firm licensing by the European multinational corporation SKF in the 1970s to finance its corporate R&D unit in the Netherlands by having its European subsidiaries pay royalties for their IP use.[45] Intra-firm licensing and royalty payments are also frequently used by MNCs for shifting income and lowering corporate taxes.[46]

Fourth, new extra types of IPRs, i.e. *sui generis* IPRs, might be needed in the course of time for innovation governance involving new types of technologies, although the IPR system over centuries has shown with some exceptions to be quite able to accommodate new technologies without too serious misfits. Database rights provide a case in point as the idiosyncrasies of production, refinement, and distribution of data are magnified by digital information and communication technologies beyond what has traditionally been conceived of as the defining characteristics of acts of creation and invention as grounds for granting traditional IPRs. The continuous cumulation at

43 See F Scott Kieff, 'Coordination, Property & Intellectual Property: An Unconventional Approach to Anticompetitive Effects & Downstream Access' 56 Emory Law Journal 327 (2006).

44 A requirement to disclose information about an invention in return for some patent-like rights or privileges goes back to medieval times in Europe but was in general not entering statutory patent laws in Europe until the 19th and 20th century.

45 See Ove Granstrand and Ingemar Fernlund, 'Coordination of Multinational R&D' 9 (1) R&D Management 1-7 (1978). A similar set-up was allegedly used by Bell Labs in the past.

46 See Granstrand (n 6) ch 10.6.9.

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high rates of large amounts of new data in the form of very long bit strings with missing data and unknown errors and relevant coordinates, produced by multiple actors and artefacts in networks (such as AI agents in the Internet of Things) with uncertain user values provides many worthy problems for legislators and market designers to attack.

Fifth, if IPRs are functional for governance through incentivizing and coordinating inventive and innovative activities, it is natural to ask if firms could create additional extra-legal IP rights systems on their own, compatible with the legislated ones in society. In fact, firms do so, although to limited extents so far, apart from instances like traditional reward schemes for internal ideas and industry traditions, governing e.g. IP exchange and standard setting. The growth of open innovation justifies more attention and attempts to create organization-specific proprietary extra-legal IPR systems through some kind of private ordering.[47]

VII. Other institutional arrangements for innovation governance

Finally, what other institutions or arrangements for governance are comparable to IPRs and possibly useful as complements and/or substitutes? One approach is to integrate property rights with liability rules and apply them circumstantially.[48] Since a property right consists of a bundle of rights (to use and dispose, to exclude, to trade, to benefit), parts of this bundle could be combined with some liability rules and adapted to different situations according to economic considerations as mentioned above.[49] Thus, one could for example remove the right to exclude patent infringers by means of injunctions from using the infringed technology, and replace that right with a right to claim royalties from the infringer, who is then liable to pay these royalties. A certain movement in this direction seems to have taken place, at least in the US, especially after the US Supreme Court decision in the *eBay* case.[50] More generally, a liability to pay royalties for infringement instead of an obligation to stop using the infringed technology could be welfare enhancing even under the constraint that the infringed party should not be worse off by this allocation of rights and liabilities (i.e. a Pareto improvement), and thus justifiable in the utilitarian consequential underpinnings of the patent system as a whole. There are many advantages of this type of hybrid property/liability bundle approach to technology and innovation governance, advantages stemming from the nature of new technologies, e.g. being uncertain (especially in early stages when codifiability is low and protective scope difficult to delineate properly *ex ante*), dynamic, recombinant and cumulative. Other advantages stem from better functioning of technology and IP markets and the flexibility of license rights relative to property rights. In fact, challenges from certain new IP phenomena, e.g. non-practicing entities (NPEs), could likely be better met by a hybrid property/liability approach. There are also disadvantages, e.g. increased legal and economic uncertainty and problems of how to assess and distribute damages and royalties to compensate for them. Courts may be reluctant and less competent to take on that burden and may prefer to be lenient towards the use of markets for valuations and royalty setting. However, a liability approach can be used where private parties negotiate a license and a royalty rate, perhaps in the shadow of compulsory licensing with a judicial rate setting. Willingness to license could moreover be incentivized at the patent granting stage. These types of institutional arrangements then require better methods for IP valuations and FRAND-based royalty setting. Compulsory licensing in turn is controversial, but perhaps unnecessarily so since there are no clear signs that it is harmful to R&D and innovation.[51] Compulsory licensing is nevertheless not a necessary component in a liability approach since there are circumstances under which some form of private ordering likely would work.[52] Finally, it may be argued that the options for institutional arrangements for innovation governance are not exhausted and institutional innovations of hybrid property/liability approaches, be they private or state orderings, may appear once innovativeness is fostered by abandoning a strict property approach to IP.[53]

47 Examples are IP rights allocations in crowdsourcing of ideas, eg for Apple or Android apps, or outsourcing of platform application developments. Other examples are non-suit pacts or pledges and other forms of IP volunteering and conditional donations of IP, as well as various licensing schemes connected to open source movements and the like, such as Creative Commons licenses.

48 As suggested in the seminal article by Guido Calabresi and A Douglas Melamed, 'Property Rules, Liability Rules, and Inalienability: One View of the Cathedral' 85 (6) Harvard Law Review 1089-128 (1972). For subsequent works developing this approach further, see Robert P Merges, 'Contracting into Liability Rules: Intellectual Property Rights and Collective Rights Organizations' 84(5) California Law Review 1293-393 (1996), Jerome H Reichman and Tracy Lewis, 'Using Liability Rules to Stimulate Local Innovation in Developing Countries: Application to Traditional Knowledge' in Keith E Maskus and Jerome H Reichman (eds), *International Public Goods and Transfer of Technology Under a Globalized Intellectual Property Regime* (Cambridge University Press 2005) 337-66, Mark A Lemley and Philip J Weiser, 'Should Property or Liability Rules Govern Information?' 85 (4) Texas Law Review 783-841 (2007) and Mark A Lemley, 'Contracting around Liability Rules' 100 (2) California Law Review 463-86 (2012).

49 As mentioned above, some scholars consider property rights absolute in the sense that they imply a core of rights as defining characteristics, such as the right to exclude, and therefore are impossible to unbundle and reject without abandoning them as property rights, ie without depropertization. This type of conceptualization of property rights is rooted in a Western school of thought and is unnecessarily constraining thinking about institutional design. Here patent rights and IPRs are taken in a broader sense, not requiring strict excludability. Intellectual rights might then be a better term than intellectual property rights, although the latter term has gained prominence but strictly speaking is preferable at most for property-like rights.

50 See Daniel A Crane, 'Intellectual Liability' 88 (2) Texas Law Review 253-300 (2009) and Merges (n 35).

51 See eg Frederic M Scherer, *The Economic Effects of Compulsory Patent Licensing* (New York University Monograph Series in Finance and Economics 1977) for a classic thorough study and Colleen V Chien, 'Cheap Drugs at What Price to Innovation: Does the Compulsory Licensing of Pharmaceuticals Hurt Innovation?' 18 (3) Berkeley Technology Law Journal 853-907 (2003) and Frederic M Scherer and Jayashree Watal, 'Competition Policy and Intellectual Property: Insights from Developed Country Experience' (Faculty Research Working Paper Series RWP14-013), Cambridge, MA: Harvard Kennedy School 2014 for more recent ones.

52 For a critique of compulsory licensing of copyrights and an advocacy of private ordering through private liability rules in cases of recurrent contracting, epitomized by collective rights organizations, see Merges (n 48) and Robert P Merges, 'Compulsory Licensing vs. the Three "Golden Oldies": Property Rights, Contracts, and Markets' 508 Policy Analysis 1-15 (2004).

53 It is noteworthy that the critics of the patent system, eg Michele Boldrin and David K Levine, 'The Case against Patents' 27 (1) Journal of Economic Perspectives 3-22 (2013), Dan L Burk and Mark A Lemley, 'The Patent Crisis and How Courts Can Solve It' (UC Irvine School of Law Research Working Paper No 2009-8, Stanford Law and Economics Olin Working No 370; Stanford Public Law Working Paper No

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Another approach of particular interest from a governance perspective is to compare the allocation of property rights and their associated usage rights with the ordinary managerial allocation of responsibilities in an organization, which is an arrangement of a non-market hierarchical kind of governance. The question then is to what extent an organizational responsibility is property-like (and liability-like) and conversely to what extent a property right (and a liability) is responsibility-like, and finally what other relations there are between rights and responsibilities.[54] This is apparently a novel comparative perspective.[55] A first attempt to compare a governance regime based on property rights and a governance regime based on organizational responsibilities reveals a number of similarities. Both regimes allow for control of resources with grounds for revocation, both have mechanisms for dispute resolution, and so on. A key similarity is that they enable the allocation of usage rights through licensing in the case of property rights and through delegation of authority in the case of responsibilities. In both cases decision rights derived from property rights are handed out as a means to decentralization in the governance structure. Allocation of usage rights disintegrated from ownership rights, implying in fact a separation of ownership and control, could be exercised for governance purposes for intellectual as well as for physical resources, where in the latter case leasing should be considered a form of licensing. As for IPRs and responsibilities for R&D and innovative activities, they share many of the similarities between their physical counterparts, at the same time as they are both fuzzier and more difficult, and thereby costly, to delineate and enforce than their physical counterparts.

Apart from different ways to fulfill a certain governance function, there are some key differences as well in functionalities between property rights and responsibilities, e.g. regarding granting, duration, accountability, liability, transferability and modes of enforcement. Excludability derived from property rights is used to govern the distribution of competitive advantages on a market while excludability based on organizational responsibilities are used for division of labor and gaining collaborative advantages. Infringement of property rights as well as of organizational responsibilities may occur by chance or by intention but are treated differently, usually with the use of the equivalents of injunctions and exemptions (e.g. for fair use) and less stringent excludability in organizations. A specific difference between IPRs and responsibilities for R&D and innovative activities is the maintenance and limited duration of IPRs, which do not apply to responsibilities or to physical property rights.

Thus, there are similarities and differences between property rights and organizational responsibilities in general as well as between IPRs and responsibilities for R&D and innovative activities more specifically. Such similarities and differences, of which only a few have been described here for expositional purposes, motivate a probe for substitutability and complementarities, empirically as well as theoretically. For example, the similarities provide possibilities to bridge property rights theory with organization theory.[56] A follow-on question is then if two such regimes could be combined more synergistically beyond just co-existing as institutional complements in a market economy. The use of private ordering through extra-legal IPRs as mentioned above is then an example of how quasi-legal constructs could be combined with organizational responsibilities. This approach could be taken one step further by viewing it as one particular form of combining property rules, organizational rules and liability rules in a contractual infrastructure.[57] At the same time such a hybrid approach to innovation governance runs the risk of becoming overly complex and thus might incur increasing administrative costs and uncertainties. The final overriding question then is when and how property rules, organizational rules and liability rules could and should be combined for governance of IP and innovation in a technology-driven knowledge-based capitalist economy, i.e. an economy of the intellectual capitalism variety.[58] This large demanding question must be left open for further research.

VIII. Summary and conclusions

Much attention has been paid to the question of how to govern economic activities in general, while much less attention has been paid to the issue of how to govern R&D and innovative activities specifically, despite the general consensus about the *sine qua non* role of new technologies and innovations for economic performance. The nature of new technologies and the ways innovative activities are organized have moreover changed drastically over the years, which calls into question whether the traditional economic and legal institutions – markets,

1349950, 2009), Adam B Jaffe and Josh Lerner, 'Reinventing public R&D: Patent policy and the commercialization of natural laboratory' 32 (1) RAND Journal of Economics 167-198 (2001), and Bessen and Meurer (n 37), and their suggestions for patent reforms do not address a liability approach. While there is a rich literature on the liability approach in general and a rich literature on the property approach to IP, there is (so far) much less written on hybrid property/liability approaches to patents and IP.

54 The question could be extended to include how an organizational responsibility compares with a liability, being a kind of legal responsibility.

55 The nature and consequences of separation of ownership and control in corporate governance is a related but more specific issue and not particularly concerned with ownership and control of intellectual resources.

56 As an example, one possibility is to thereby refine the analysis of Coase's classical example with an upstream firm imposing costs to a downstream firm through a negative externality in form of water pollution. As argued in a Coasian analysis, an integrated firm would through allocation of organizational responsibilities achieve the same production outcome (but not equity outcome) as any allocation of private property rights in the water in case transaction costs are negligible. In fact, zero transaction costs are sufficient but not necessary for the theorem to go through, only that transaction costs are on par with management costs. The Coase theorem can moreover with some additional assumptions be extended to apply to situations involving R&D and new technologies in the two firms, in which case allocation of IPRs across firms might govern innovation in a similar way as allocation of organizational responsibilities for R&D in a joint firm, in which R&D may be performed in various internal organizational structures (work in progress).

57 As an example, the private ordering of dispute resolution through the management hierarchy or some form of arbitration then corresponds to court ordering of market disputes.

58 At a higher level of inquiry, one can probe the implications of such an approach or variants thereof for the relative innovativeness of a market-led capitalist economy like that in the US compared to a state-led capitalist economy like that in China or some form of a mixed economy in between these two polar types. Again, in a Coasian spirit such an approach could be hypothesized to be a possible substitute for some government regulatory intervention in innovation. At the same time traditional Coasian analysis misses out on technological innovations, which might need public or private collective intervention to get started in case of market failures, eg related to increasing returns as argued in W Brian Arthur, *Increasing Returns and Path Dependence in the Economy* (The University of Michigan Press 1994), in which case a hybrid approach could arguably be designed as a complement rather than a substitute to regulatory intervention.

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firms, property rights, courts, etc. – are functioning satisfactorily for governing innovative activities in an economy. Recent empirical studies have for example shown the frequent appearance of quasi-integrated organizational forms for innovative activities, 'in between' the polar types of market and hierarchical firm organizations, today commonly referred to as 'open innovation'. Many rationales for engaging in open innovation have been offered in the literature, but still this phenomenon needs to be better understood theoretically. More generally, there is a need to theorize about how innovative activities are incentivized and coordinated, i.e. governed, in markets, in hierarchies and in mixes thereof, and the role of IPRs in that context. These are issues that this paper has explored on a road less travelled in the hope that further research will follow.

The nature of R&D and innovative activities has changed dramatically after WW2 with increasing levels of total R&D investments, dispersion of R&D across countries and companies, total returns to R&D albeit with fluctuating rates, technological diversity across firms and innovations, technological genericness, and the organizational scale of R&D and innovative activities, often crossing firm boundaries. As a result of these interrelated trends, input resources and outputs from innovative activities are increasingly traded on various types of markets, implying different degrees of organizational disintegration or equivalently degrees of 'openness' in innovation.

This paper has presented a reinterpretation of open innovation in terms of the emergence of various types of markets for inputs to and outputs from innovative activities. These open innovation markets are typically markets for ideas, technologies, knowledge and data such as licensing markets, equity markets, and matching markets for innovation collaborations. The open innovation markets moreover correspond to various types of open innovation strategies viewed from the inside out from a focal firm's perspective. The explanations of the open innovation phenomenon are then explanations in terms of determinants behind the supply and demand side of the various types of open innovation markets. A number of key determinants of demand and supply on open innovation markets have been identified, such as technological levelling of companies and countries, technological genericness, technological diversification, division of R&D labor and specialization, needs to finance R&D and innovation, and the expansion and strengthening of the IPR system. Many of these drivers increase both demand and supply but not necessarily simultaneously, rather over time. The determinants are moreover interrelated, which typically makes technology markets interrelated both as to their transacting subjects and their transaction objects. The quasi-integrated nature of open innovation with a mix of markets and management through hierarchies is then explainable in terms of economizing on dynamic relative costs for innovation production and governance.

The standard transaction cost economic framework then has to be extended to explicitly take management costs and total governance costs into account.

IPRs play an important role in economizing on innovation governance costs, and the paper elaborates on the role of IPRs as tools for innovation governance, which is a fairly new perspective on IPRs. An IPR system provides a contractual infrastructure which provides a pre-contract market signaling function, a set of pre-defined and standardized contractual arrangements, and rules for reaching as well as transferring or trading contractual agreements and mechanisms for their enforcement, even post-contractually. Property rights in tangibles provide similar important functionalities, but the intrinsically more complex nature of intellectual resources and IPRs compared to physical resources and property rights in them makes the availability and functioning of such a contractual infrastructure even more important for well-functioning development, trade and transfer of intellectual resources. However, a comparative analysis of the nature of tangible and intangible (intellectual) resources and rights reveals such inherent differences that a strict property approach to intellectual resources is hard to justify on economic grounds with the corollary that IPRs rather should be referred to as intellectual rights if the concept IPRs had been less entrenched. Nevertheless, the institutions created for granting rights in new technological ideas and information (inventions), i.e. the patent system, could in principle (apart from parametric features like inventive step, duration of rights, etc.) be derived from the physiological characteristics of human information processing and the need for facilitating market exchange of information across humans in more developed societies.

The view (or emerging paradigm) of IPRs as governance tools at various levels leads to several issues to probe, such as the value of disclosure, licensing and supplementary public or private rights. Licensing of usage rights rather than allocation of ownership rights is key to using IPRs as tools for innovation governance. Through a wide array of possible contract clauses, licenses could be tailored as to when, where, how and by whom rights to intellectual resources could be used, even to replicate an open source type of innovative activities or various types of IP volunteering or to support the objectives of non-profit organizations, collectivities or regulatory entities. Contractual platforms for licensing with modules of clauses, possibly standardized, could moreover be built into a contractual architecture in order to economize on transaction costs as well as transaction times, possibly adapted to the use of 'smart contracting' supported by AI and spurred, e.g. by IoT. The paper is not normative but has pointed to some possibilities for micro-legal reengineering of bundles of sub-rights and obligations in the IPR system and also to extend the IPR system with *sui generis* rights in data as well as with a privately ordered extra-legal system for improved governance of innovative activities.

Finally, there are other institutional arrangements for innovation governance that are conceivable as complements to IPRs. One approach discussed and advocated in the paper is to integrate property rights with liability rules and apply them circumstantially. Since a property right consists of a bundle of rights (to use and dispose, to exclude, to trade, to benefit), parts of this bundle could be combined with some liability rules and adapted to different situations according to economic considerations, also taking into account costs of administration, legal complexities, and difficulties in economic valuations.

Another approach of particular interest from a governance perspective is to compare allocation of property

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rights and their associated usage rights with the ordinary managerial allocation of responsibilities in an organization, which is an arrangement of a non-market hierarchical kind of multi-level governance. This is apparently a novel comparative perspective which could help bridge organization theory and transaction cost economics with property rights theory. The paper makes a first attempt to compare a governance regime based on property rights and a governance regime based on organizational responsibilities with Coase's classical question of how to internalize a negative externality through rights allocation as an illustration.

The overriding issue is when and how a hybrid approach with property rules, organizational rules and liability rules could and should be combined for governance of innovative activities. This is a large question demanding much further research work on the road towards a more integrated theory of innovation governance.

ACKNOWLEDGEMENTS

The helpful comments from Prof Bengt Domeij, JD Thomas Ewing and two anonymous referees are gratefully acknowledged as is the editorial assistance of Andreas Opedal. Financial support has been provided by the Swedish Innovation Agency Vinnova under grant 2017-04469.

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